(B1)

Your mailroom stamp hereon will acknowledge receipt by Express Mail No. EV 554213965US a new international patent application consisting of Transmittal Letter to the United States Receiving Office (1 page); a PCT Request (5 pages); a PCT ANNEX - FEE CALCULATION SHEET (1 page); PCT Application (30 pages); PCT Drawings (Figs 1-9) (13 pages); 1 PCT-SAFE Diskette; and our check in the amount of $3,436.00 for:

(December 14, 2005- 1046_008PCT) IM/cl

Applicant: Spectra Logic Corporation
Title: VARIABLE MEDIA TAPE-BASED STORAGE SYSTEM
Earliest priority date claimed: December 14, 2004
Filed: December 14, 2005
and has been given International Application No. PCT/US05/45168 ✓

IAP3 Rec'd PCT/PTO 14 DEC 2005

✓

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL LETTER TO THE UNITED STATES RECEIVING OFFICE

Express Mail mailing number: EV554213965US	Date of deposit: 14/12/2005
File reference no.: 1046_008PCT	International application no. (if known): New International Patent Application

Title of invention: VARIABLE MEDIA TAPE-BASED STORAGE SYSTEM

Earliest priority date claimed (Day/Month/Year): 14/12/2004

☒ **This is a new International Application**

SCREENING DISCLOSURE INFORMATION:

In order to assist in screening the accompanying international application for purposes of determining whether a license for foreign transmittal should and could be granted and for other purposes, the following information is supplied. (check as many boxes as apply):

☐ The invention disclosed was **not** made in the United States of America.

☐ There is no prior U.S. application relating to this invention.

☒ The following prior U.S. application(s) contain subject matter which is related to the invention disclosed in the attached international application. *(NOTE: priority to these applications may or may not be claimed on the Request (form PCT/RO/101) and this listing does not constitute a claim for priority.)*

application no.	11/011,812	filed on	14/12/2004
application no.		filed on	

☐ The present international application contains additional subject matter not found in the prior U.S. application(s) identified above. The additional subject matter is found on pages _____ and ☐ **DOES NOT ALTER** ☐ **MIGHT BE CONSIDERED TO ALTER** the general nature of the invention in a manner which would require the U.S. application to have been made available for inspection by the appropriate defense agencies under 35 U.S.C. 181 and 37 C.F.R. 5.15.

Itemized list of contents

Sheets of Request form: 5	Check no.: 15243
Sheets of description (excluding sequence listing): 21	Return receipt postcard: Enclosed
Sheets of claims: 8	Power of attorney:
Sheets of abstract: 1	Certified copy of priority document (specify):
Sheets of drawings: 13	Other (specify): Fee calculation sheet (1 page); and one diskette.
Sheets of sequence listing:	
Sequence listing diskette/CD:	I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail under Express Mail Label No. EV554213965US in an envelope addressed to: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on December 14, 2005.
Tables related to sequence listing CD:	By: Cynthia Losurdo Cynthia Losurdo

The person signing this form is:	☐ Applicant	
	☒ Attorney/Agent (Reg. No.) 46,944	Indranil Mukerji Name of person signing
	☐ Common Representative	Signature

This collection of information is required by 37 CFR 1.10 and 1.412. The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 15 minutes to complete, including gathering information, preparing, and submitting the completed form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORM TO THIS ADDRESS. **SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PCT REQUEST

Original (for **SUBMISSION**)

0	**For receiving Office use only**	
0-1	International Application No.	
0-2	International Filing Date	
0-3	Name of receiving Office and "PCT International Application"	

0-4	**Form PCT/RO/101 PCT Request**	
0-4-1	Prepared Using	PCT-SAFE [EASY mode] Version 3.50 (Build 0002.175)
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	United States Patent and Trademark Office (USPTO) (RO/US)
0-7	**Applicant's or agent's file reference**	1046_008PCT
I	**Title of Invention**	VARIABLE MEDIA TAPE-BASED STORAGE SYSTEM
II	**Applicant**	
II-1	This person is	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	SPECTRA LOGIC CORPORATION
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III-1	**Applicant and/or Inventor**	
III-1-1	This person is	applicant and inventor
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III-1-6	State of nationality	US
III-1-7	State of residence	US

PCT REQUEST

Original (for **SUBMISSION**)

III-2	**Applicant and/or inventor**	
III-2-1	This person is	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	RECTOR, Richard Douglas
III-2-5	Address	6123 Salvia Ct. Arvada, CO 80403 United States of America
III-2-6	State of nationality	US
III-2-7	State of residence	US
III-3	**Applicant and/or inventor**	
III-3-1	This person is	applicant and inventor
III-3-2	Applicant for	US only
III-3-4	Name (LAST, First)	LANTRY, Mark Lorin
III-3-5	Address	2942 Indigo Circle North Fort Collins, CO 80528 United States of America
III-3-6	State of nationality	US
III-3-7	State of residence	US
III-4	**Applicant and/or inventor**	
III-4-1	This person is	applicant and inventor
III-4-2	Applicant for	US only
III-4-4	Name (LAST, First)	BARR, John David
III-4-5	Address	3517 Blenca Peak Court Superior, CO 80027 United States of America
III-4-6	State of nationality	GB
III-4-7	State of residence	US

PCT REQUEST

Original (for **SUBMISSION**)

IV-1	**Agent or common representative; or address for correspondence**	
	The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	MUKERJI, Indranil
IV-1-2	Address	Wall Marjama & Bilinski LLP 101 South Salina Street Suite 400 Syracuse, NY 13202 United States of America
IV-1-3	Telephone No.	(315) 425-9000
IV-1-4	Facsimile No.	(315) 425-9114
IV-1-5	e-mail	imukerji@wallmarjama.com
IV-1-6	Agent's registration No.	46,944
V	**DESIGNATIONS**	
V-1	**The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.**	
VI-1	**Priority claim of earlier national application**	
VI-1-1	Filing date	14 December 2004 (14.12.2004)
VI-1-2	Number	11/011,812
VI-1-3	Country	US
VI-2	**Priority document request**	
	The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)

PCT REQUEST

Original (for **SUBMISSION**)

VIII	**Declarations**	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	**Check list**	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	5	✓
IX-2	Description	21	-
IX-3	Claims	8	-
IX-4	Abstract	1	✓
IX-5	Drawings	13	-
IX-7	TOTAL	48	
	Accompanying Items	paper document(s) attached	electronic file(s) attached
IX-8	Fee calculation sheet	✓	-
IX-17	PCT-SAFE physical media	-	✓
IX-19	**Figure of the drawings which should accompany the abstract**	Fig. 2A	
IX-20	**Language of filing of the international application**	English	
X-1	**Signature of applicant, agent or common representative**		
X-1-1	Name (LAST, First)	MUKERJI, Indranil	
X-1-2	Name of signatory		
X-1-3	Capacity		

PCT REQUEST

Original (for **SUBMISSION**)

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	
10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/EP
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	

1046_008PCT

PCT (ANNEX - FEE CALCULATION SHEET)

Original (for **SUBMISSION**)

(This sheet is not part of and does not count as a sheet of the international application)

0	**For receiving Office use only**				
0-1	International Application No.				
0-2	Date stamp of the receiving Office				
0-4	**Form PCT/RO/101 (Annex) PCT Fee Calculation Sheet**				
0-4-1	Prepared Using	PCT-SAFE [EASY mode] Version 3.50 (Build 0002.175)			
0-9	**Applicant's or agent's file reference**	1046 008PCT			
2	**Applicant**	SPECTRA LOGIC CORPORATION			
12	**Calculation of prescribed fees**		fee amount/multiplier	Total amounts (USD)	
12-1	Transmittal fee	T	⇨	300	
12-2-1	Search fee	S	⇨	1877	
12-2-2	International search to be carried out by		EP		
12-3	International filing fee (first 30 sheets)	I1	1102		
12-4	Remaining sheets		18		
12-5	Additional amount	(X)	12		
12-6	Total additional amount	I2	216		
12-7	i1 + i2 =	I	1318		
12-12	EASY Filing reduction	R	-79		
12-13	Total International filing fee (i-R)	I	⇨	1239	
12-14	Fee for priority document Number of priority documents requested		1		
12-15	Fee per document	(X)	20		
12-16	Total priority document fee:	P	⇨	20	
12-17	**TOTAL FEES PAYABLE (T+S+I+P)**		⇨	3436	
12-19	**Mode of payment**		cheque		
12-20	**Deposit account Instructions** The receiving Office		United States Patent and Trademark Office (USPTO) (RO/US)		
12-20-2	Authorization to charge any deficiency or credit any overpayment in the total fees indicated above		✓		
12-21	Deposit account No.		50-0289		
12-22	Date		14 December 2005 (14.12.2005)		
12-23	Name and signature		Indranil Mukerji		

VARIABLE MEDIA TAPE-BASED STORAGE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Patent Application No. 11/011,812 filed on December 14, 2004, of which application is hereby incorporated by reference in its entirety

FIELD OF THE INVENTION

[0002] The present invention relates generally to retrieving data from, and storing data to, a variable medium storage system by means of communications intended for a tape library.

BACKGROUND

[0003] Tape libraries have historically been the primary storage devices for amassed digital data. This has been due in part because of the tape libraries' ability to store considerably large amounts of data in a cost-efficient and data-stable manner. Other types of storage systems containing alternative media such as disc drives, however, are beginning to gain momentum as a consequence of advancements in the technology. Disc drive-based systems generally facilitate an additional level of flexibility in the way data is stored. Depending on the configuration of the storage system, the random access functionality of disc drives can dramatically speed up data transfer between a host and storage system. Such advances are evident in a Virtual Tape Library (VTL) which is a leading alternative to the traditional tape library.

[0004] VTLs are generally promoted as faster, more versatile backup systems than the traditional tape-based libraries. A VTL works by emulating legacy tape libraries by operating with standard tape backup software, such as Veritas backup software from Veritas Corporation of Mountain View, California. Put simply, a VTL presents the appearance of a tape library of almost any make and model to a host.

[0005] FIG. 1 shows a prior art block diagram of the relationship between a VTL 100 and a host computer 102 over a network communications path 106. The VTL 100 is comprised of an array of disc drives 108 often configured in a RAID (Redundant Array of Independent Discs [drives]). Here, for purposes of simplicity, the VTL RAID system 108 is comprised of four disc drives 104. The disc drives 104 function as one virtual disc drive 120 capable of sharing a single article of data, such as a file, across multiple disc drives 104. This feature enables data to be saved and retrieved at fast rates because an article/s of data can be accessed in a parallel fashion. In the event a disc drive 104 fails in the RAID 108, the data on any given drive 104 can be reconstructed from redundant data on other disc drives 104 which provides a bonus feature over a conventional tape library. As previously discussed, the VTL 100 appears to be a tape library 110 to the host computer 102, which in this configuration, is constructed with three tape drives A 112, B 114 and C 116 and twenty-four tapes, or tape articles, such as tape article [1] 122.

[0006] In one example, the host computer 102 can communicate over the communications path106 with the VTL 100, to query the configuration of the VTL 100. The VTL 100 can respond indicating that it is a tape library 110 with twenty-four tape articles and three drives (A 112, B 114 and C 116). The host 102 can communicate a request to send data packages to tape articles [1] 122, [2] 124 and [3] 126 to be loaded in

tape drives A 112, B 114 and C 116, respectively. The host 102 receiving such a positive response over the communications path106 from the VTL 100 sends data via the communications path 106 to the VTL 100 to be saved on tape articles [1] 122, [2] 124 and [3] 126. The VTL 100, in turn saves the data across the disc drives 104 in the RAID 108 as if they were three tape articles [1] 122, [2] 124 and [3] 126 on the virtual drive 120.

[0007] Unlike conventional tape libraries wherein tape articles can be removed from the library and archived and replaced with new or blank tapes to provide additional storage space, the VTL 100 is typically limited to the size of the RAID 108. This has been addressed by enlarging the RAID with additional disc drives 104 or adding additional RAID systems. The components and effort required to enlarge the RAID, however, often is substantially greater than that associated with increasing storage space in conventional tape libraries.

SUMMARY OF THE INVENTION

[0008] The present invention relates generally to retrieving data from and storing data to a variable medium storage system by means of communications intended for a tape library and overcomes the disadvantages and limitations of the prior art by providing a method and apparatus for directing data storage intended for a target tape article and target tape drive associated with the tape library to a selected mobile storage element and drive pair associated the storage system.

[0009] Embodiment of the present invention can therefore comprise a variable media tape based storage system comprising: a plurality of drives; at least one media

element compatible with at least one of said drives for storing and receiving data wherein a loaded drive is one of said drives and said compatible media element configured to operate as a functional pair; a switch system and map system operatively linked to each of said plurality of drives; said storage system adapted to alter at least one received and accepted tape library command from positioning a target storage tape article for use with a target tape drive to selecting one of said loaded drives via said switch system and map system.

[00010] Embodiment of the present invention can further comprise a method for using a variable media tape based storage system comprising: receiving a command in streaming protocol from a host to position a first target tape article for use with a first target tape drive; selecting a first drive of a plurality of drives loaded with a first compatible media element; designating said loaded first drive with said first compatible media as said first target tape article positioned for use with said first target drive; responding to said host in said streaming protocol affirming said command is accomplished.

[00011] Embodiment of the present invention can further comprise a means for using a variable media tape based storage system comprising: means for receiving a command in streaming protocol from a host to position a first target tape article for use with a first target tape drive; means for selecting a first drive of a plurality of drives loaded with a first compatible media element; means for designating said loaded first drive with said first compatible media as said first target tape article positioned for use with said first target drive; means for responding to said host in said streaming protocol affirming said command is accomplished.

[00012] Embodiment of the present invention can further comprise a variable media tape based storage system comprising: at least one of a plurality of drives loaded with at least one media element having a compatible read and write relationship with said at least one drive; said storage system adapted to select said loaded drive in the place of a tape library command from a host to position at least a first target tape article for use with at least a first target tape drive and respond to said host that said library command is accomplished.

[00013] Embodiment of the present invention can further comprise a data storage system for storing and retrieving data for a host computer programmed to operate as a tape library comprising: at least one non-tape drive; a map system containing information regarding data stored in the system; and a switching element that directs, based on the map system, data to and from said drives such that said storage system operates as a virtual tape library.

[00014] Embodiment of the present invention can further comprise a data storage system comprising: at least one non-tape drive; a mapping means for representing information stored in the storage system as a virtual tape library; and a switching means linked to each of said drives.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a prior art communicating Virtual Tape Library and a host computer over a network communications path.

FIG. 2A is a block diagram of a variable media tape-based storage system in communication with a host constructed in accordance with an embodiment of the present invention using a switch and map system.

FIG. 2B shows an alternative embodiment of an out-of-band communications path mapping system for a storage system.

FIG. 2C is a block diagram of a variable media tape based storage system in communication with a host constructed in accordance with an embodiment of the present invention using an interface bridge processor system.

FIG. 3A is a pictorial representation of a typical tape library.

FIG. 3B is a perspective drawing of a tape media magazine article consistent with an embodiment of the present invention.

FIG. 4 is a perspective view of a combination tape and disk drive magazine storage system host constructed in accordance with an embodiment of the present invention.

FIG. 5A is a perspective view of a tape drive accommodating a digital tape cassette consistent with embodiments of the present invention.

FIG. 5B is an exploded perspective view of a mobile disc drive magazine and disc drive magazine docking station consistent with embodiments of the present invention.

FIG. 6 is a block diagram illustrating a functionality embodiment consistent with embodiments of the present invention.

FIG. 7 shows a flow diagram of a method for using a variable media tape based storage system in accordance with an embodiment of the present invention.

FIG. 8 shows an alternative embodiment of FIG. 7 wherein receiving and storing data steps are included in accordance with an embodiment of the present invention.

FIG. 9 shows an alternative method for FIG. 8 wherein the steps illustrate using the storage system with multiple storage elements consistent with embodiment of the present invention.

DETAILED DESCRIPTION

[00015] Referring to the drawings in general, and more specifically to FIG. 2A, shown therein is a block diagram of a variable media tape-based storage system 201 in communication 204 with a host computer 202 constructed in accordance with an embodiment of the present invention. In what follows, similar or identical structure is identified using identical callouts.

[00016] In the arrangement of FIG. 2A, the host computer 202 could be a personal computer, a mainframe computer, a server, or any computer system linked to the storage system 201, just to name a few examples. The communication path 204, at a minimum, needs only to facilitate communication between the host computer 202 and the storage system 201. The communication means could be accomplished by a dedicated pathway or, in an alternative embodiment, a pathway over a network for example. Furthermore, the communication path could be in the form of a wire line pathway, wireless, or a combination thereof, for example.

[00017] The storage system 201, in this embodiment, is comprised of a plurality of locations wherein drives can be disposed which, as shown here, can include at least one tape drive 222 and at least one disc drive magazine docking station 228. Each drive, such as the tape drive 222, is operatively linked for communication over a communications data path 206 to a switching system 240. In this case, the communications data path 206

is provided between the switching system 240 and the drives in each location, such as the empty location 232 for example. For illustrative purposes, the means for communicatively linking 206 the drives, such as the tape drive 222, to the switching system 240 is shown here to be accomplished by wires; however this could be done by wireless entirely or by a combination of wire and wireless, just to name some examples. The communications protocol means between the host 202 and the switch system 240 could be the same as or compatible with the communications data path 206 within the storage system 201, such as fiber channel for example, or different such as fiber channel at the arrow 204 and SCSI (Small Computer System Integration) across the communication links 206 in the storage system 200. In this configuration, there are twelve drive positions numbered consecutively with the following designations: [1] 221, [2] 222, [3] 223, [4] 224, [5] 225, [6] 226, [7] 227, [8] 228, [9] 229, [10] 230, [11] 231 and [12] 232. Drive positions [1] 221, [11] 231 and [12] 232 are empty or unloaded. In this embodiment, storage system 201 is in communication 204 with the host computer 202 via the switch system 240 which may be physically included with the storage system 201 or, alternatively, disposed outside the storage system 201. Finally, the storage system 201 is capable of storing and retrieving data for the host 202 as if the storage system 201 were a typical tape library capable of receiving and accepting tape library communications, such as SCSI tape protocol communication.

[00018] In this embodiment, the switch system 240 is operable with a map system 242 capable of altering the identification of each location wherein a drive can be disposed, such as location [1] 221 or [2] 222 for example. A map system is capable of defining, or mapping, any one of the locations as a target location to fulfill storage access

request/s from the host 202. One example of a map system 242 is a software "mirror" of a tape library for example. Here, the map system 242 is in communication 244 with the switch system 240 in what is considered "in-band communication", which is communication over the data stream 206. In one example, the host 202 could request communications with a drive A loaded with tape media No. 3 by means of a normal tape library communications protocol, the map system 242 could go through the switch system 240 and designate loaded location [7] 227 as being drive A loaded with tape media No. 3 in the virtual sense, then the switch system 240 could create a path between the host computer 202 and the designated location [7] 227 for communications. In this example, the map system 242 is capable of renumbering the locations by a mapping means, such as a software program, to accommodate host 202 access commands, for example. In this embodiment the map system 242 is separate from the switch system 240. However, this is not a limitation, since the map system 242 and the switch system 240 could be physically and/or functionally combined.

[00019] FIG. 2B shows an alternative embodiment of an out-of-band communications path mapping system 242 for the storage system 203. Here, the map system 242 could be linked 252 for communication with all of the locations capable of comprising storage devices, such as location [1] 221 or [2] 222 for example. The mapping of location for switching identification is over the out-of-band path 252 and not over the data path 206 or through the switch system 240. The mapping system 242, in this embodiment, is in communication with the host 202 through the switch system 240 over the path 250. It should be clear to a skilled artisan that the out-of-band mapping

storage system 203 is illustrative and conceptually is not limited to the construction of FIG. 2B.

[00020] FIG. 2C shows an illustrative embodiment of the present invention wherein the mapping and switching functions are assumed in an interface bridge processor 212 in the storage system 200. The communication between the interface bridge processor 212 and the drives could be through a protocol specific to the storage system 200 and different from the communication protocol 204 from the host 202. The protocol specific to the storage system 200 could take into account the type communication link 206, drive addresses, such as drive [1] 221, or drive type, such as a tape drive 222 supporting a particular tape cassette (not shown) just for example.

[00021] FIG. 3A has been provided to illustrate a typical tape library 300. Here, a tape library 300 can comprise a plurality of tape articles, such as a tape cassette 342, disposed in a cassette container 340. The tape library 300 is adapted with support structure 304 having storage locations 306 capable of accommodating the tape media, such as a target tape cassette 342, when not being used by a tape drive, such as a target tape drive 350. In this case, the support structure 304 is a shelving unit positioned inside of the library 300.

[00022] In this tape library 300, the target tape cassette 342 is supported by a tape cassette container 340 and can be transported from a storage location 306, and positioned to the target tape drive 350 for data storage use or from the target tape drive 350 back to the storage location 306. Here, the means for positioning the target tape cassette 342 is accomplished by a robotics device capable of positioning a grasping device, in this case a picker 316, and a magazine transporting support structure 308 to at least the storage

locations 306 and tape drives, such as the target tape drive 350. In this example, the picker 316 and the magazine transport support structure 308 are connected to a belt 314 and motorized pulley system 320 capable of moving the picker 316 and support structure 308 up and down the tape library 300 as illustrated by the vertical two way arrow 312. The motorized belt 314 and pulley system 320 is supported by a horizontal transport system 322 capable of moving the picker 316 and support structure 308 to the front 330 and the back 332 of the library 300, as shown by the horizontal two way arrow 310. In this example, the components described in the tape library 300 are substantially contained within an enclosure 302.

[00023] In one illustration of the tape library 300, the positioning system 314, 320 and 322 positions the picker 316 to grasp and transfer a tape cassette container 340 containing the target tape article 342, from a storage location 306 to the magazine support structure 308. A target tape article 342, in this example, is a tape cassette containing information desired by a user or host 202. The positioning system 314, 320 and 322 then positions the tape cassette container 340 containing the target tape cassette 342 to the target tape drive 350 in a way to facilitate the picker 316 to transfer the target tape cassette 342 from the tape cassette container 340 in position for use with the target tape drive 350. The target tape drive 350 is generally the tape drive that the host 202 commands the tape library 300 to use with the target tape cassette 342.

[00024] In the above scenario, the single tape 342 can be considered a target tape article although in an alternative embodiment of the tape library 300, the entire tape magazine 301 could be considered a target tape article. In some tape libraries the tape magazine media element 301 is used as a single tape article organized to store data across

multiple tape cassettes 342 in a tape cassette container 340 as if they were a single tape media element. For example, the tape magazine 301 could contain tape 1A 371, tape 1B 372, and so on, all being considered tape article 1 corresponding to the entire tape magazine article number [1] 301.

[00025] While the claimed invention has utility in any number of different applications, the combination tape and disc drive magazine storage system 400 of FIG. 4 has been provided to illustrate a particularly suitable environment for the present invention. For purposes of illustration, this particular combination storage system 400 embodiment is constructed to be diagrammatically consistent with the storage system block diagram 200. Hence, the combination storage system 400 is constructed with twelve receiving bays 412 capable of substantially containing twelve drives numerically configured like FIG. 2A. This combination storage system 400 further comprises loaded tape drives 404, such as at location [2] 222, an unloaded tape drive 402 at location [1] 221, loaded disc drive magazine docking stations 406, such as at location [3] 223, an unloaded disc drive magazine docking station 408 at location [11] 231 and an empty bay 412 at location [12] 232 capable of receiving either the tape drive 402, the disc drive magazine docking stations 408 or some other drive adapted to function with the empty bay 412, such as a drive capable of reading and writing to optical media for example. A loaded drive is a drive and compatible media element configured to operate as a functional pair, such as the tape cassette 410 inserted in the tape drive 404 operating as a functional pair to store and retrieve data. The combination storage system 400 is adapted to electrically connect all of the drives to an interface bridge processor 212. The means

of electrical connection could be by wire connections, wireless, such as radio frequency for example, or any combination or equivalents thereof, just to name a few.

[00026] FIG. 5A shows perspective view of a loaded tape drive 404 in detail. Here, the loaded tape drive 404 is adapted to cooperate with the tape cassette 410 by partially containing the tape cassette 410 for storing and retrieving data. In this example, the cassette 410 is received by an opening in the face 502 of the tape drive 404. The tape drive 404 is capable of being engaged by a storage system 200 and electrically connected 206 with an interface bridge processor 212. As directed to the combination storage system 400, the tape drive 404 is capable of being proportioned to be engaged and substantially contained by one of the twelve bays 412.

[00027] FIG. 5B shows an exploded perspective view of a mobile disc drive magazine 500 and a disc drive magazine docking station 408. Here, a plurality of disc drives 508 are substantially contained by an enclosure 504 generally comprising the mobile disc drive magazine 500. The mobile disc drive magazine 500 is adapted to be received by an opening 510 in the mobile disc drive magazine docking station 408. The insertion of the mobile disc drive magazine 500 into the disc drive magazine docking station 408 forms the loaded drive 408 and media element 500 pair 406. The disc drive magazine docking station 408 is capable of being electrically connected with the interface bridge processor 212, or other device/s by a coupling means via the disc drive magazine docking station 408, such as wires, wireless, plugs-in, or any combination or equivalence thereof, just to name a few examples. The enclosure 504 shows an example of an identification (ID) bar code 512 for identifying the mobile media element 500, such as for archiving in a remote storage location for example. In one embodiment, the mobile disc

drive magazine 500 could be configured to operate as a RAID (Redundant Array of Independent Disc [drives]) device.

[00028] Referring now to FIG. 6, shown therein is a block diagram illustrating some functionalities of an embodiment of the present invention. Here, a host computer 202 is in communication 204 with the storage system 200 via the interface bridge processor 212. The interface bridge processor 212 is also communicatively linked 206 to all of the drives 214 of the storage system 200. The storage system 200 is capable of communicating 204 with the host computer 202 by using a streaming protocol, such as a SCSI tape protocol, as if the storage system 200 was a conventional tape library 600. The storage system 200, in turn, is capable of functioning based on its own internal storage system protocol. This variable protocol communication is accomplished through the interface bridge circuit 212 which acts as a translator capable of translating the two communication protocols between the host 202 and the storage system 200. Hence, the tape library block diagram 608 represents virtual communication between the host 202 and a tape library 600 wherein the actual communication is between the host 102 and storage system 200.

[00029] To better understand the communications relationship between the host computer 202 and storage system 200 as specifically pertaining to the operations of the illustrative storage system 200, a simplified example of the basic operations of an embodiment of the present invention will now be provided. For purposes of illustration, as previously described, the storage system block diagram 200 may diagrammatically represent the combination storage system 400. In this embodiment, storage system 200 is configured with nine loaded drives 214 which include loaded tape drives 404 and loaded

disc drive magazine docking stations 406, for example. Here, the host computer 202 could query the storage system 200 to determine the physical configuration of the storage system 200 for purposes of sending specific storage related commands. The storage system 200 through the interface bridge processor 212 could reply that it is a tape library 600 containing nine tape cassettes, such as cassette [1] 621, wherein each tape cassette has a certain amount of storage capacity, in addition to containing three tape drives being tape drive A 602, tape drive B 604 and tape drive C 606. The host computer 202 could then issue a command to load three target tapes, tapes [1] 621, [2] 622 and [3] 623, into the target tape drives A 602, B 604 and C606 respectively. The loading operation in the tape library 600 can be accomplished with a robotic system for moving a target tape, such as tape cassette [1] 621, from an archive location, such as 306, generally in the library 600 to a target tape drive, such as A 602, whereby the target tape [1] 621 is typically inserted in an opening in the target tape drive A 602, such as shown in FIG. 5A for example, where storing and retrieving information can take place. In response to the issued command from the host computer 202, the interface bridge processor 212 could select the loaded drives in position [2] 222, [3] 223 and [4] 224 and assign the designation that they are virtually the target tapes [1] 621, [2] 622 and [3] 623 loaded in the target tape drives A 602, B 604 and C606 respectively. Referring back to FIG. 4, the loaded drives [2] 222, [3] 223 and [4] 224 are the loaded tape drive 404, and two loaded disc drive magazine docking stations 406. The interface bridge processor 212 could then respond to the host 102 that the tape loading command to load target tapes [1] 621, [2] 622 and [3] 623 into target tape drives A 602, B 604 and C606 respectively is accomplished. The host 102 could then initiate a storage related command, such as to

read or write data for example, as if the storage system 200 were the tape library 600. Hence, a loaded drive, such as a loaded disc drive magazine docking station 406, can be selected and activated by the interface bridge processor 212 which can eliminate conventional robotic tape cassette manipulation for use with a tape drive in a conventional tape library. In another embodiment of this example, tape cassettes could be substituted by any other tape article, such as a tape article configured as a tape magazine article 301 without departing from the present invention.

[00030] On advantage of the embodiments described in FIG. 6 is that the storage system 200 adapted to save data on each mobile media element, such as the disc drive magazine 500, autonomously. Autonomous data on a mobile media element enables the archiving of each media element in an off-site location for safe keeping, for example. This facilitates a replenishment of media elements enabling the storage system 200 access to unlimited, cost-effective storage capacity, which is one of the benefits of a tape library. Furthermore, by selecting a loaded drive by simply assigning an address by means of an interface bridge processor 212 can eliminate robotic systems physically positioning tape articles for use with a drive, thus enhancing efficiency and reliability in the storage system 200. Finally, because the media elements are not limited to tape, such as 410, inherent strengths of different kinds of media can be taken advantage of depending on the needs of a user.

[00031] Referring now to FIG. 7, shown therein is a method to practice an embodiment of the present invention. It should be recognized that the steps presented in the described embodiments of the present invention do not require any particular sequence. In step 702, the storage system 200 receives a streaming protocol command

from a host 202 to position a target tape, such as [1] 621, for use with a target tape drive, such as tape drive A 602. A means for receiving the streaming protocol command could be over wire lines, such as cable, or wireless, such as RF, just to name a couple examples, whereby an interface bridge processor 212 could be adapted to receive the command for the storage system 200, for example. In step 704, one of a plurality of drives loaded with a compatible media element is selected. The loaded drive, as previously disclosed, is a drive and compatible mobile media element configured to operate as a functional pair. A means for selecting a loaded drive with a compatible media element could be by an algorithm (such as a software program for example) for use with the interface bridge processor 212, for example. As shown in block 706, the storage system 200 designates the selected loaded drive as if it were the target tape and the target drive. A means for designating the selected loaded drive could be performed by a switching circuit disposed in the interface bridge circuit 212 backed by a software address allocation routine capable of determining which loaded drive (wherein the loaded drives would be configured to have addresses) in the storage system 200 would be appropriate, just to name one example. The final block 708 is a step in which the storage system 200 responds to the host 202 in the streaming protocol (that the host 202 understands) indicating that the command in the receiving step 704 is accomplished. A means for responding to the host 202 could be done through the interface bridge circuit 212 in the streaming protocol that is understood by the host 202, for example.

[00032] FIG. 8 is an alternative embodiment of the present invention which includes method steps 702, 704, 706 and 708 from FIG. 7. Step 802 is a block in which the storage system 200 receives a data storage command from the host 202 to store data

on the target tape with the target tape drive in streaming protocol. A means for receiving the data storage command could be one of the embodiments of the means described for step 704. In step 804, the storage system 200 stores the data from step 802 on the designated loaded drive from step 706. A means for storing the data could be accomplished by a loaded disc drive magazine docking station in communication 206 with an interface bridge circuit such as over a SCSI wire system using a protocol that is supported by the disc drive magazine docking station and the SCSI wire system, for example.

[00033] FIG. 9 is another alternative method to practice the present invention. In step 902 of this embodiment, the storage system 200 receives a first and second streaming protocol command from a host 202 to position a first target tape, such as [1] 621, for use with a first target tape drive, such as tape drive A 602, and a second target tape, such as [2] 622, for use with a second target tape drive, such as tape drive B 604 respectively. A means for receiving the streaming protocol command could be one of the embodiments of the means described for step 702. In step 904, a first loaded drive and second loaded drive from a plurality of drives having a first and second compatible media element are selected. A means for loading the drives with the compatible media could be one of the embodiments of the means described for step 704. In step 906, the storage system 200 designates the selected first and second loaded drives as if they were the first and second target tapes and target drives, respectively. A means for designating the selected loaded drive could be one of the embodiments of the means described for step 706. In step 908, the storage system 200 responds to the host 202 in the streaming protocol (which the host 202 understands) indicating that the first and second commands

in the receiving step 904 is accomplished. A means for responding to the host 202 could be one of the embodiments of the means described for step 708. Step 910 is a block in which the storage system 200 receives a first data storage command from the host 202 to store first data on the first target tape with the first target tape drive in streaming protocol. In step 912, the storage system 200 stores the first data from step 910 on the first designated selected loaded drive from step 906. Step 914 is a block in which the storage system 200 receives a second data storage command from the host 202 to store second data on the second target tape with the second target tape drive in streaming protocol. In step 916, the storage system 200 stores the second data from step 914 on the second designated selected loaded drive from step 906. A means for receiving the data storage commands could be one of the embodiments of the means described for step 704. A means for storing the data could be one of the embodiments of the means described for step 804.

[00034] Embodiments of the present invention could be commercially practiced with a storage system 200 configured like the combination tape and disc drive magazine storage system 400 of FIG. 4 with RXT disc drive removable RAID magazines and RXT docking stations both produced by Spectra Logic Corporation of Boulder, Colorado and also with LTO-2 tape cassettes and LTO-2 tape drives from IBM Corporation of Dallas, Texas. The storage system 200 can be equipped with an interface bridge processor 212 primarily comprised of a QIP (Quad Interface Processor) from Spectra Logic Corp., adapted to receive and respond to a tape iSCSI (internet Small Computer System Interface) protocol communications, such as one provided by Veritas Corporation of Sunnyvale, California, from a host 202, such as a server system. The interface bridge

processor 212 can also be adapted to translate the iSCSI protocol to a protocol supported by the storage system 200, such as a fiber channel protocol, and vise versa. The storage system 200 can further comprise bays where the LTO-2 tape drives and the RXT disc drive docking stations can be installed. Each bay can be assigned an address that can be translated through to whatever drive may reside in the bay. In addition, each bay can have a connector that connects the LTO-2 tape drive or the RXT disc drive docking station to a fiber channel line, or other, that connects to the interface bridge circuit 212 creating the communications path 206 between the interface bridge circuit 212 and the drives. The storage system 200 can have an on-board computing system that operates with the interface bridge processor 212 containing software to identify the state of each bay, such as empty without a drive, empty but containing a drive without media or a drive loaded with media. Further, the software can be operable to designate loaded drives in the place of target tapes to be positioned for use with target tape drives as generally instructed by the tape protocol. The interface bridge processor 212 can then be equipped to communicate back to the host 202 as if it were a tape library indicating that target tapes have been positioned for use with target drives and the storage system 200 is ready for reading and writing data to the target tapes.

[00035] It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with the details of the structure and function of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in detail, especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by the broad general

meaning of the terms in which the appended claims are expressed. For example, storage system 200 may vary depending on the types of particular drives and media, such as the disc drive magazine docking station 408 and disc drive magazine media elements 500, the number of drives, and the manner in which the drives are ordered, the adaptability to enlarging the storage system 200 or combining multiple storage systems 200 with varying configurations and still maintain substantially the same functionality without departing from the scope and spirit of the present invention. Further, the target tape article could simply be a single tape cassette, such as the cassette 342, or an entire tape magazine article, such as the tape magazine 301 without departing from the scope and spirit of the present invention. Additionally, the functionality of the interface bridge processor, such as 212, may be in the form of a board, a chip, a switching and mapping system or equivalence, while maintaining substantially the same functionality without departing from the scope and spirit of the present invention. Finally, although the preferred embodiments described herein are directed to storage systems, such as libraries, and related technology, it will be appreciated by those skilled in the art that the teachings of the present invention can be applied to other systems, without departing from the spirit and scope of the present invention.

[00036] It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, numerous changes may be made which readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.

What is claimed is:

1. A variable media tape based storage system comprising:

a plurality of drives;

at least one media element compatible with at least one of said drives for storing and receiving data wherein a loaded drive is one of said drives and said compatible media element configured to operate as a functional pair;

a switch system and map system operatively linked to each of said plurality of drives;

said storage system adapted to alter at least one received and accepted tape library command from positioning a target storage tape article for use with a target tape drive to selecting one of said loaded drives via said switch system and map system.

2. The variable media tape based storage system of claim 1 wherein said switch system and map system are functionally comprised in an interface bridge processor.

3. The variable media tape based storage system of claim 2 wherein said interface bridge processor is adapted to receive data in a streaming protocol to be saved on said target storage tape article by said target storage drive and convert said

streaming protocol to a different protocol to save said data on said selected loaded drive.

4. The variable media tape based storage system of claim 1 wherein said switch system and map system are disposed with one of said drives.

5. The variable media tape based storage system of claim 2 wherein said interface bridge processor is capable of using tape protocol to communicate with a host and using a different communication protocol to communicate with said storage system.

6. The variable media tape based storage system of claim 1 wherein said media element and said drive is selected from the group of media and drives consisting of: mobile disc drive magazine and disc drive magazine docking station and tape cassette and tape drive.

7. The variable media tape based storage system of claim 1 wherein the media element is selected from the group of media consisting of: digital magnetic floppy disc, digital compact disc, digital flash memory device, digital tape cassette, media pack, digital tape magazine element, disc drive and mobile disc drive magazine.

8. The variable media tape based storage system of claim 1 wherein said tape library command is a tape SCSI protocol command.

9. The variable media tape based storage system of claim 1 wherein said system is an array of said drives substantially contained in an enclosure and wherein said accepted tape command appears to a host as though a first loaded drive and a second loaded drive from said loaded drives were a first storage tape article for use with a first tape drive and a second storage tape article for use with a second tape drive respectively.

10. A method for using a variable media tape based storage system comprising:

receiving a command in streaming protocol from a host to position a first target tape article for use with a first target tape drive;

selecting a first drive of a plurality of drives loaded with a first compatible media element;

designating said loaded first drive with said first compatible media as said first target tape article positioned for use with said first target drive;

responding to said host in said streaming protocol affirming said command is accomplished.

11. The method of claim 10 further comprising:

receiving a data storage command from said host to store data on said first target tape article with said first target tape drive in said streaming protocol; and

storing said data on said designated loaded first drive and first media.

12. The method of claim 10 further comprising:

receiving a second command in said streaming protocol from said host to position a second target tape article for use with a second target tape drive;

selecting a second drive from said plurality of drives with a second compatible media element;

designating said loaded second drive with said second compatible media as said second target tape article positioned for use with said second target drive;

responding to said host in said streaming protocol affirming said second command is accomplished;

receiving a first data storage command from said host to store first data on said first target tape article with said first target drive in said streaming protocol;

storing said first data on said designated loaded first drive and first media;

receiving a second data storage command from said host to store second data on said second target tape article with said second target drive in said streaming protocol;

storing said second data on said designated loaded second drive and second media.

13. The method of claim 10 wherein said designation step is accomplished by making an address assignment through an interface bridge processor.

14. The method of claim 11 wherein said storing step is done by a protocol other than said streaming protocol.

15. A means for using a variable media tape based storage system comprising:

means for receiving a command in streaming protocol from a host to position a first target tape article for use with a first target tape drive;

means for selecting a first drive of a plurality of drives loaded with a first compatible media element;

means for designating said loaded first drive with said first compatible media as said first target tape article positioned for use with said first target drive;

means for responding to said host in said streaming protocol affirming said command is accomplished.

16. The means of claim 15 further comprising:

means for receiving a data storage command from said host to store data on said first target tape article with said first target drive in said streaming protocol; and

means for storing said data on said designated loaded first drive and first media.

17. The means of claim 15 further comprising:

means for receiving a second command in streaming protocol from said host to position a second target tape article for use with a second target tape drive;

means for selecting a second drive from said plurality of drives loaded with a second compatible media element;

means for designating said loaded second drive with said second compatible media as said second target tape article positioned for use with said second target drive;

means for responding to said host in said streaming protocol affirming said second command is accomplished;

means for receiving a first data storage command from said host to store first data on said first target tape article with said first target drive in said streaming protocol;

means for storing said first data on said designated loaded first drive and first media;

means for receiving a second data storage command from said host to store second data on said second target tape article with said second target drive in said streaming protocol;

means for storing said second data on said designated loaded second drive and second media.

18. The means of claim 16 wherein said storing means is done by a means other than said streaming protocol.

19. A variable media tape based storage system comprising:

at least one of a plurality of drives loaded with at least one media element having a compatible read and write relationship with said at least one drive;

said storage system adapted to select said loaded drive in the place of a tape library command from a host to position at least a first target tape article for use with at least a first target tape drive and respond to said host that said library command is accomplished.

20. The variable media tape based storage system of claim 19 wherein said selection of said loaded drive is accomplished by using a different protocol than a host protocol used by said host for communicating said tape library command.

21. The variable media tape based storage system of claim 20 further comprising at least one data read or write command in said host protocol for said first target tape article for use with said first target drive wherein said loaded drive is adapted to carry out said data read or write command and respond to said host that said data read or write command is accomplished.

22. A data storage system for storing and retrieving data for a host computer programmed to operate as a tape library comprising:

at least one non-tape drive;

a map system containing information regarding data stored in the system; and

a switching element that directs, based on the map system, data to and from said drives such that said storage system operates as a virtual tape library.

23. A data storage system comprising:

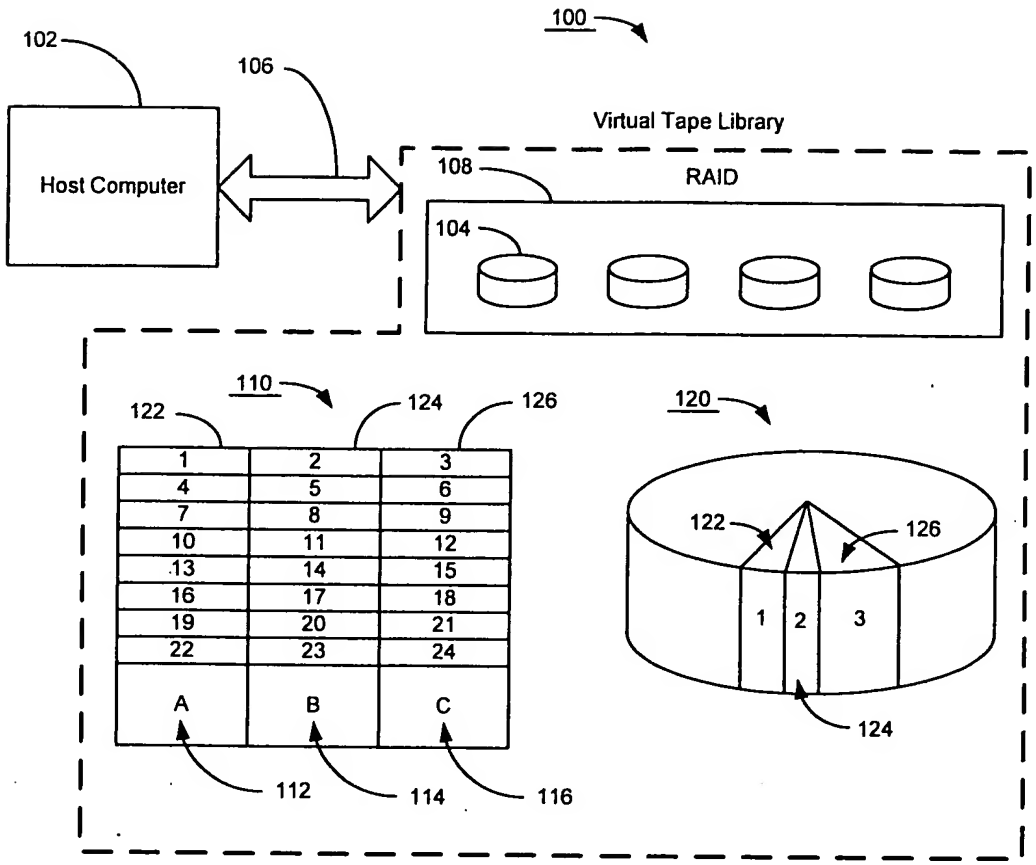
at least one non-tape drive;

a mapping means for representing information stored in the storage system as a virtual tape library; and

a switching means linked to each of said drives.

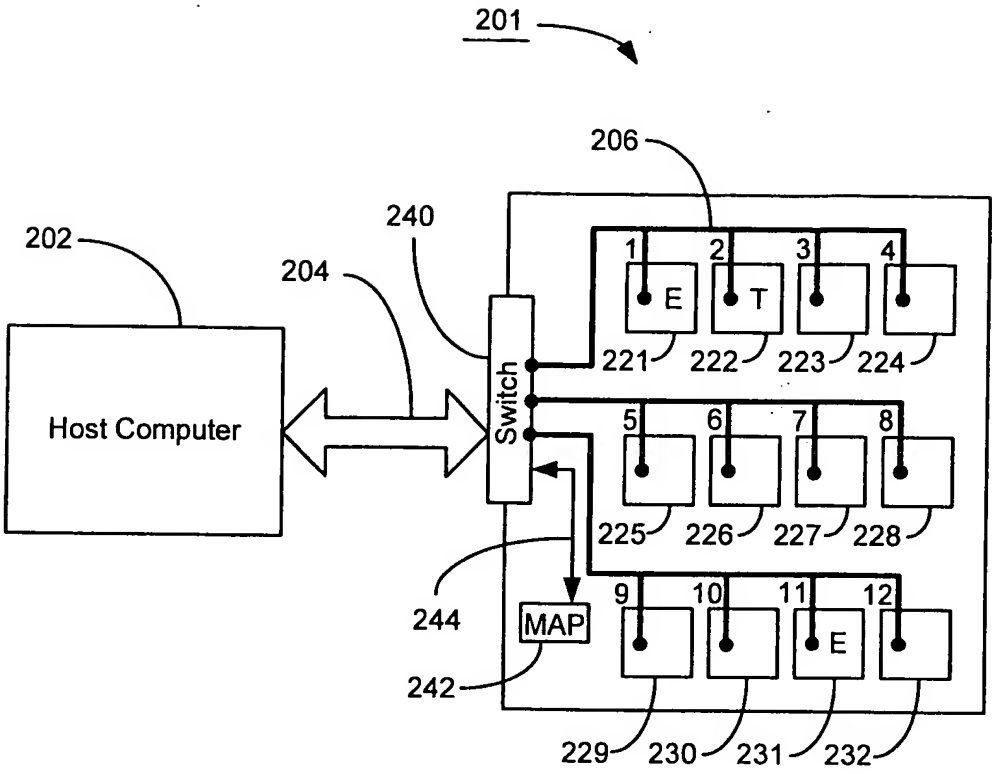
ABSTRACT OF THE DISCLOSURE

Disclosed is a method and apparatus for a variable media tape based storage system for storing, retrieving, and communicating data. The system includes at least one media element having a compatible relationship with one of a plurality of drives for storing and receiving data. The at least one media element configured to operate with the at least one drive as a functional pair is considered a loaded drive. The storage system also includes switch and mapping system, which in one embodiment could be an interface bridge processor, operatively linked to each of the plurality of drives. Finally, the storage system adapted to alter at least one received and accepted tape library command from positioning a target storage tape article for use with a target tape drive to selecting one of the loaded drives via the interface bridge processor. The interface bridge processor can be adapted to receive data in a streaming protocol to be saved on the target storage tape article by the target storage drive and convert the streaming protocol to a different protocol to save the data on the physically selected loaded drive.



PRIOR ART

FIG. 1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Host Computer
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FIG. 2A

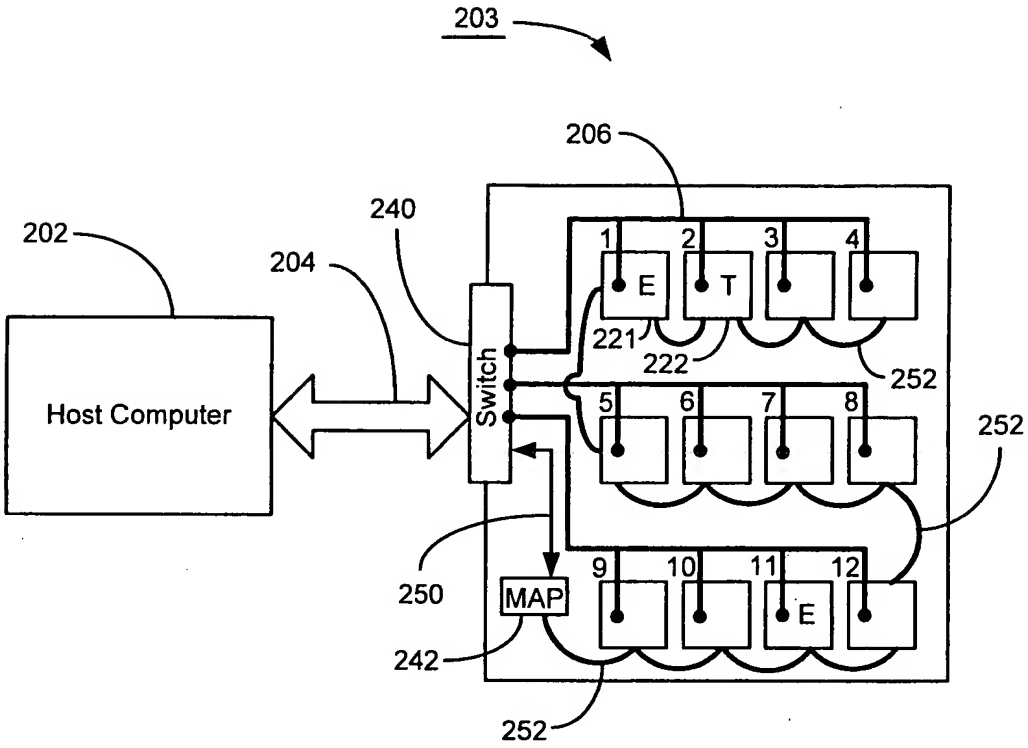
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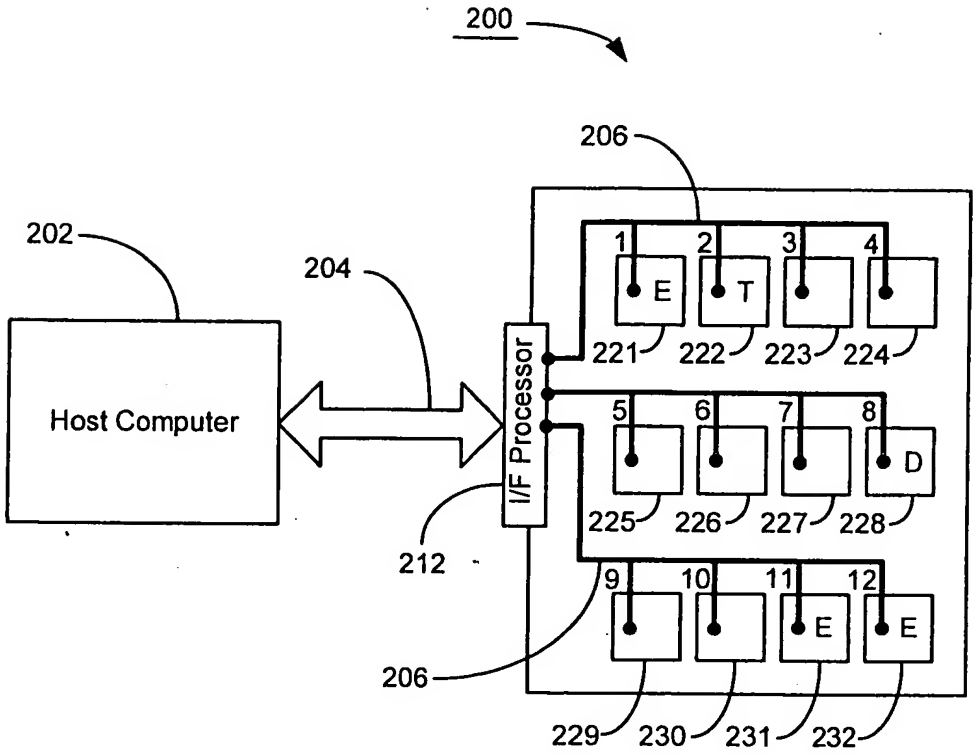
FIG. 2B


200
206
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204
Host Computer
I/F Processor
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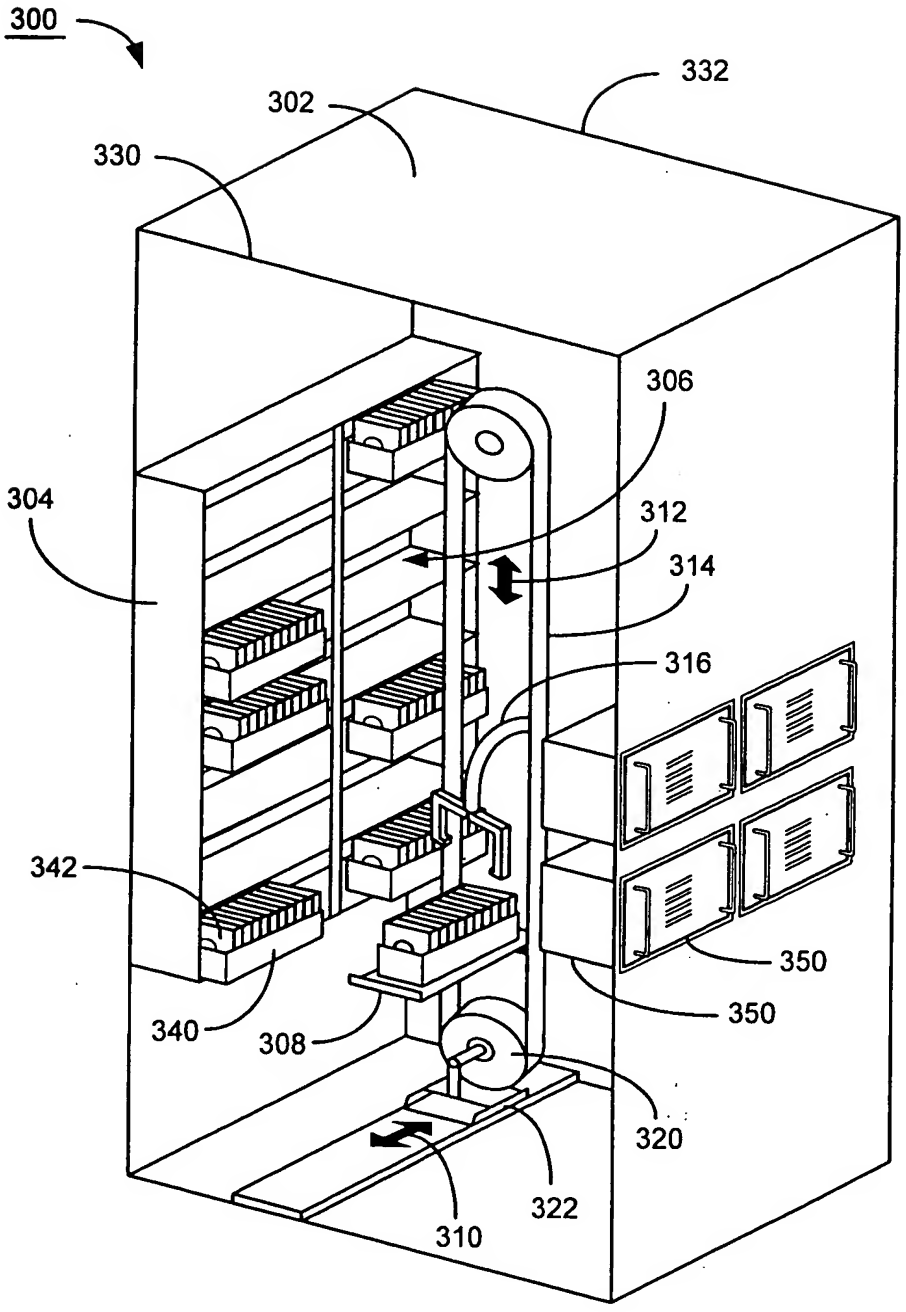
FIG. 2C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330
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342
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350
340
308
320
322
310

FIG. 3A

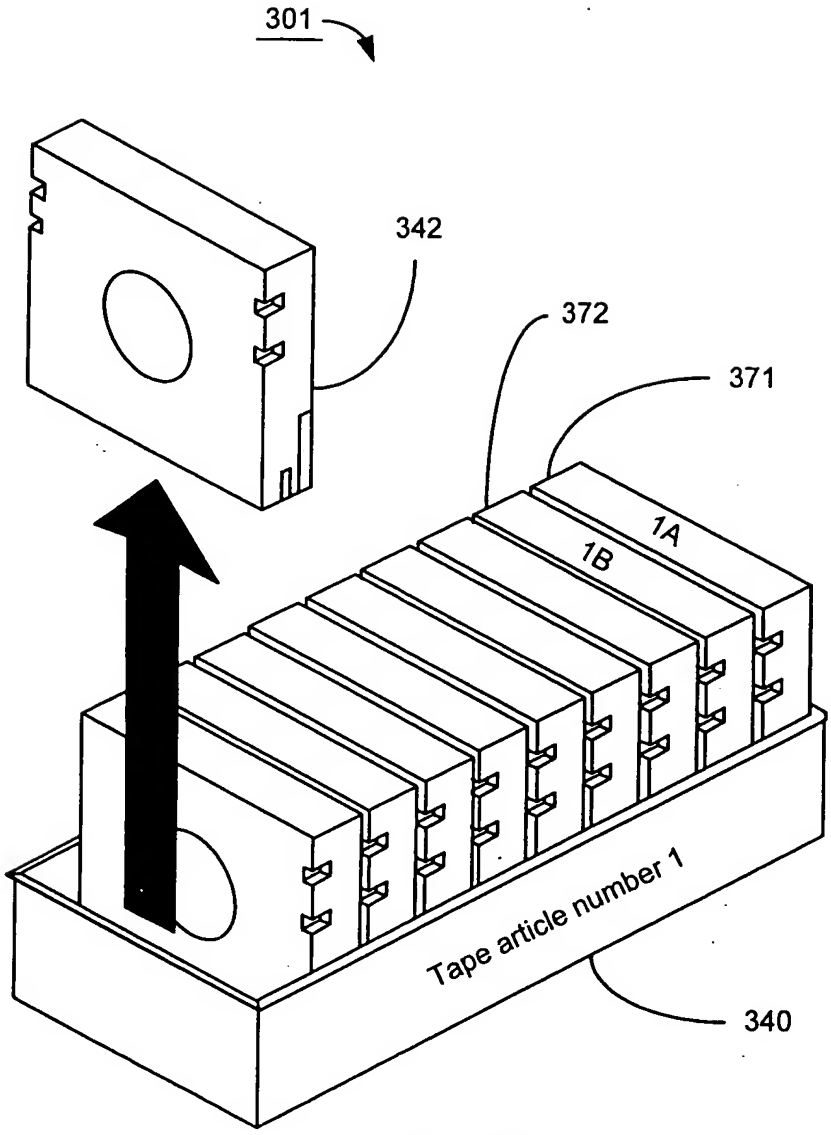
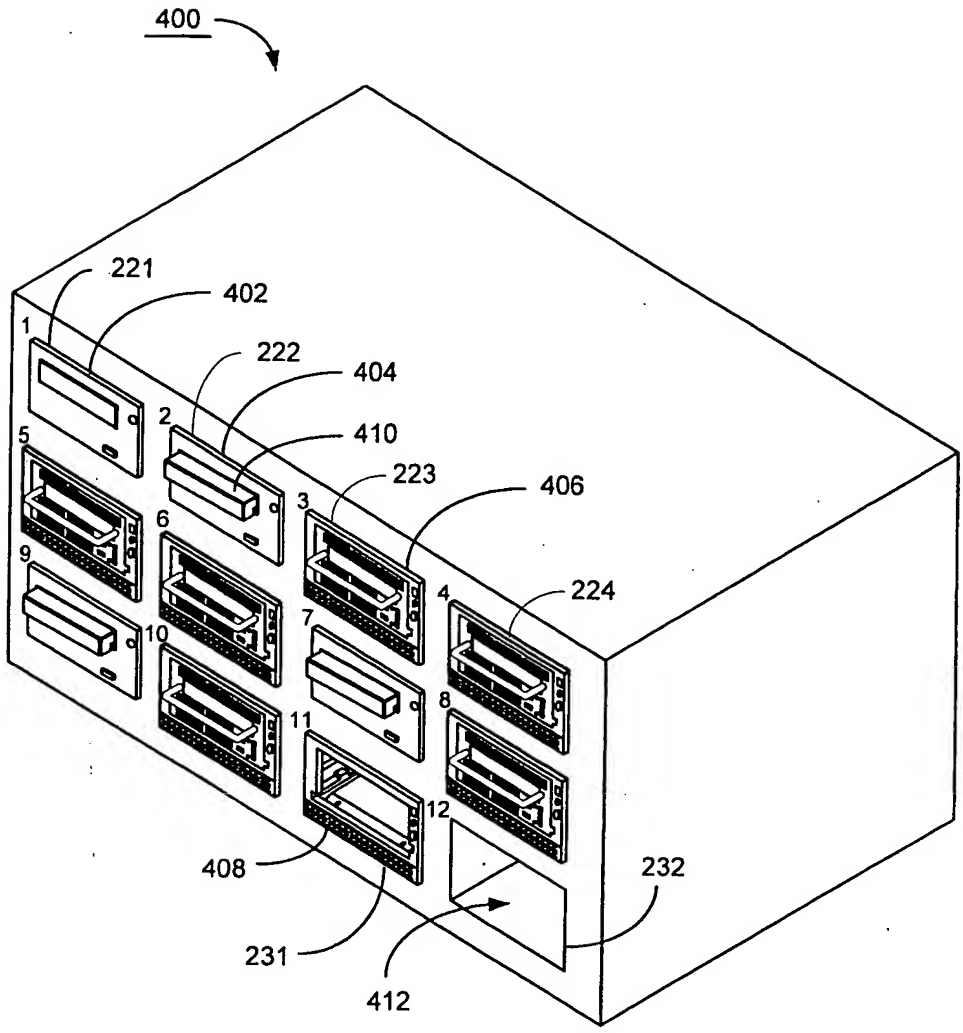


FIG. 3B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404
410
223
406
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3
4
5
6
7
8
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10
11
12
408
231
412
232

FIG. 4

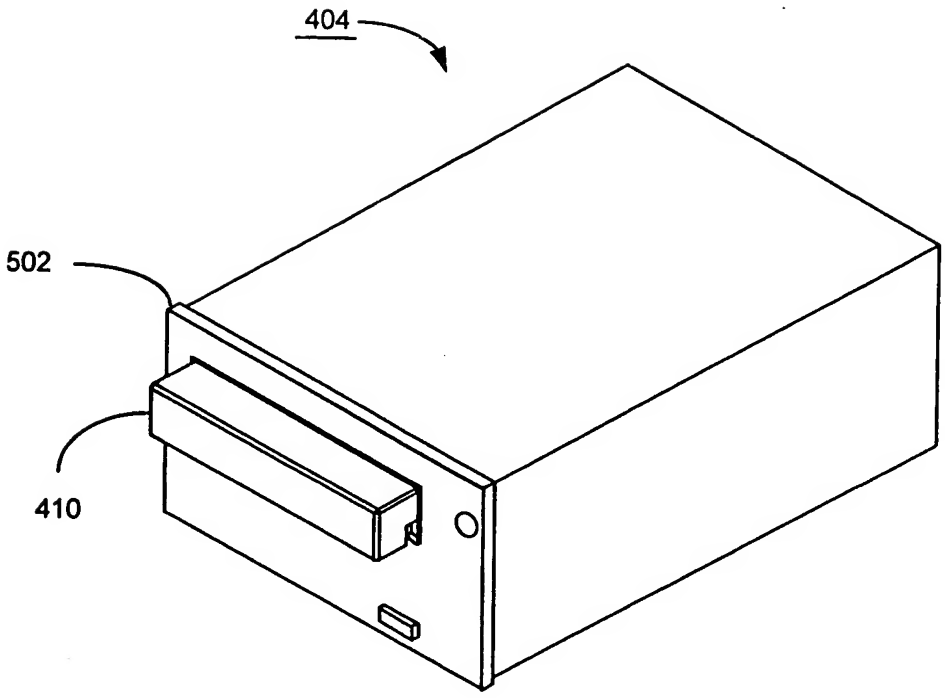


FIG. 5A

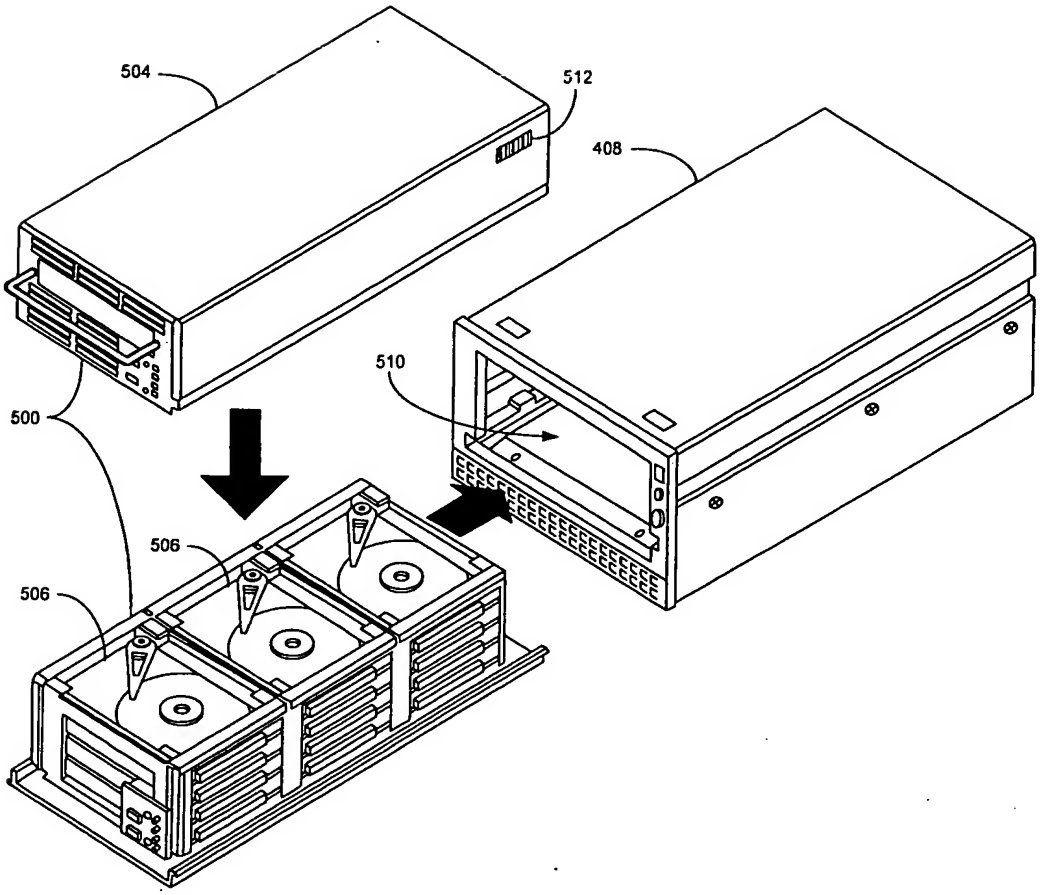
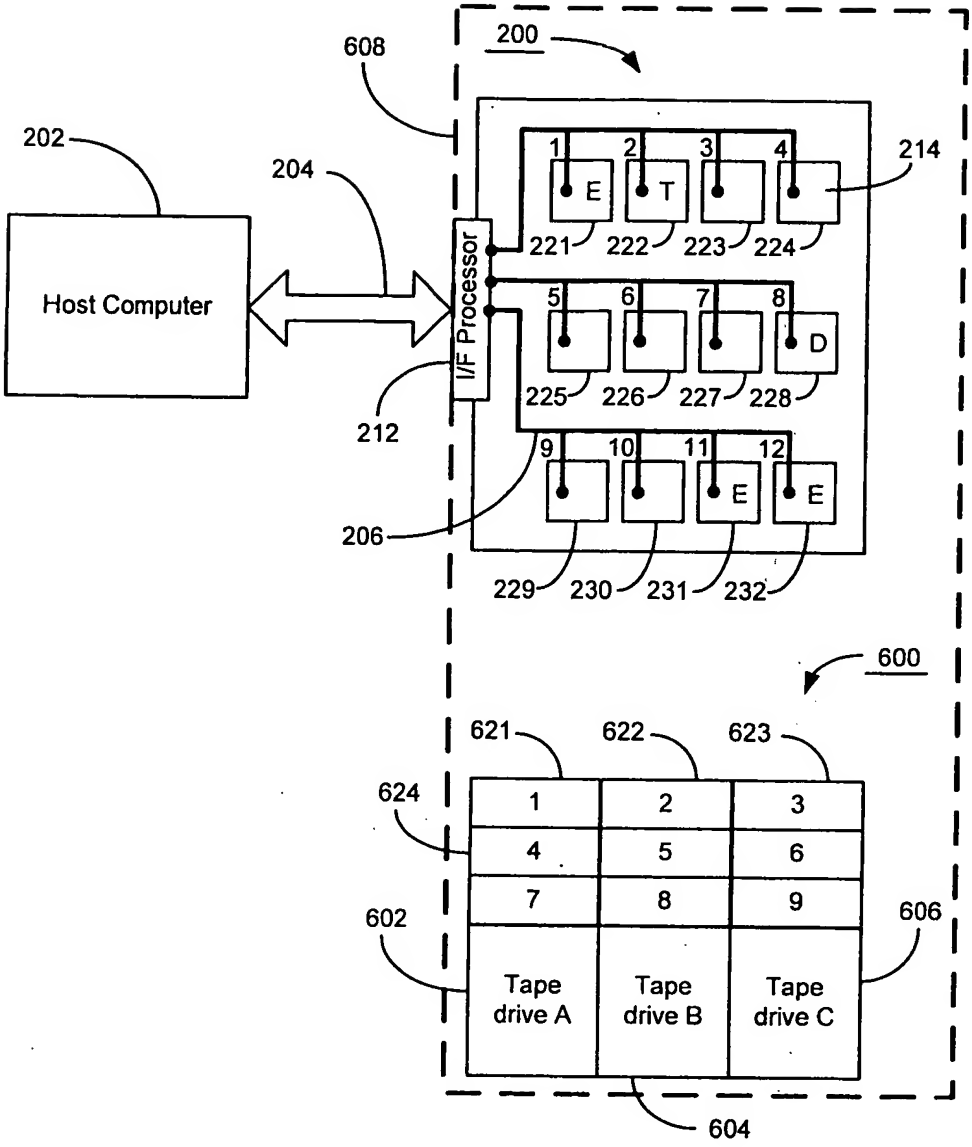


FIG. 5B


200
608
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Host Computer
I/F Processor
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232
600
621
622
623
624
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602
606
Tape drive A
Tape drive B
Tape drive C
604

FIG. 6

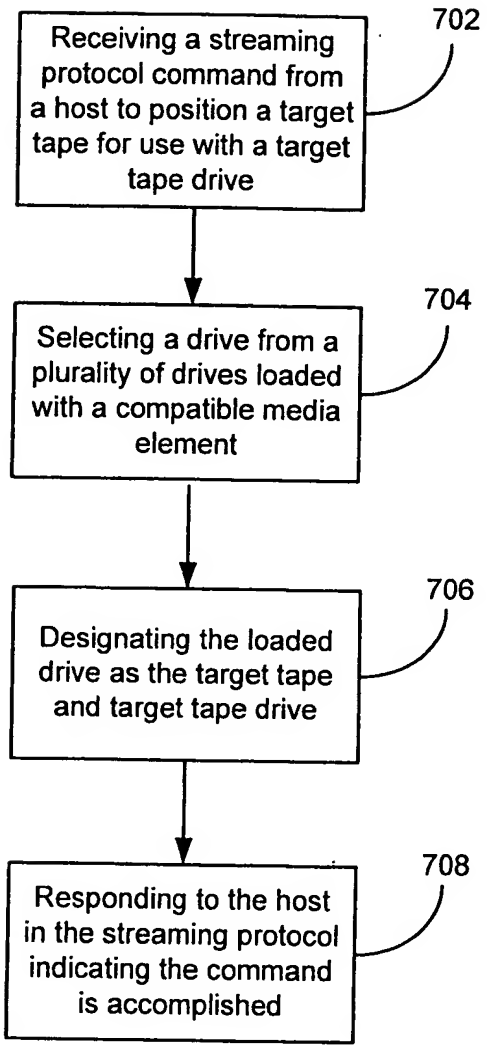
Receiving a streaming protocol command from a host to position a target tape for use with a target tape drive
702
Selecting a drive from a plurality of drives loaded with a compatible media element
704
Designating the loaded drive as the target tape and target tape drive
706
Responding to the host in the streaming protocol indicating the command is accomplished
708

FIG. 7

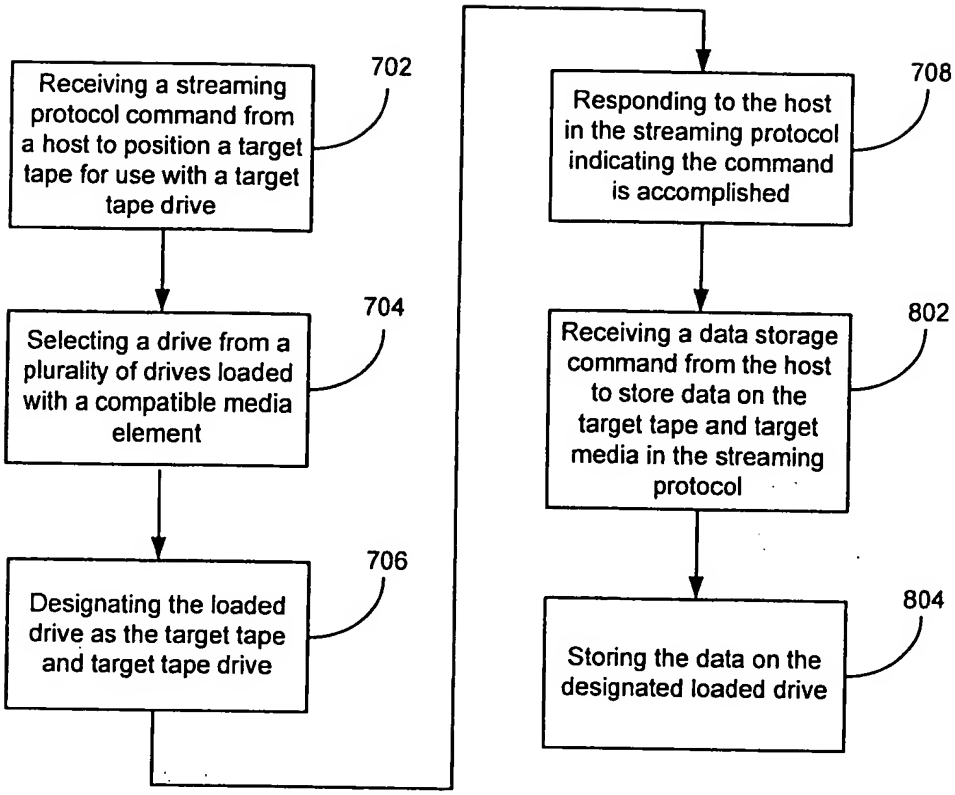
Receiving a streaming protocol command from a host to position a target tape for use with a target tape drive
702
Selecting a drive from a plurality of drives loaded with a compatible media element
704
Designating the loaded drive as the target tape and target tape drive
706
Responding to the host in the streaming protocol indicating the command is accomplished
708
Receiving a data storage command from the host to store data on the target tape and target media in the streaming protocol
802
Storing the data on the designated loaded drive
804

FIG. 8

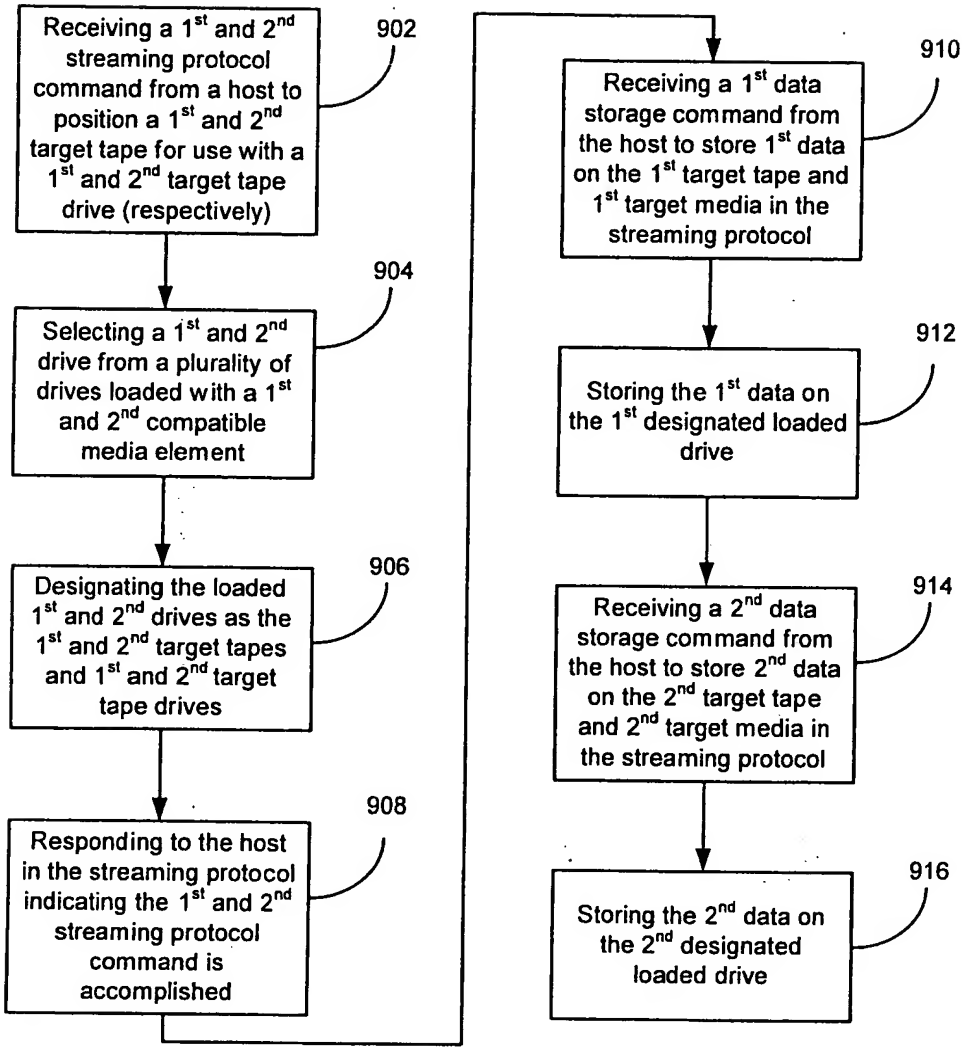
Receiving a 1st and 2nd streaming protocol command from a host to position a 1st and 2nd target tape for use with a 1st and 2nd target tape drive (respectively)
902
Selecting a 1st and 2nd drive from a plurality of drives loaded with a 1st and 2nd compatible media element
904
Designating the loaded 1st and 2nd drives as the 1st and 2nd target tapes and 1st and 2nd target tape drives
906
Responding to the host in the streaming protocol indicating the 1st and 2nd streaming protocol command is accomplished
908
Receiving a 1st data storage command from the host to store 1st data on the 1st target tape and 1st target media in the streaming protocol
910
Storing the 1st data on the 1st designated loaded drive
912
Receiving a 2nd data storage command from the host to store 2nd data on the 2nd target tape and 2nd target media in the streaming protocol
914
Storing the 2nd data on the 2nd designated loaded drive
916

FIG. 9